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00610 | Research Article

Seasonal Rhythms of Floribunda Rose Development in Cultivation Conditions in the Right-Bank Forest-Steppe of Ukraine

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Abstract

Climate change continues to intensify globally and regionally, resulting in noticeable shifts in the phylogenetic and ontogenetic characteristics of plant growth and development. Accordingly, the study aimed to investigate the influence of abiotic factors on the growth and development characteristics of floribunda roses. Seasonal dynamics of floribunda rose development in the conditions of the Right-Bank Forest-Steppe of Ukraine were examined during 2021-2023 using standard methods. The relationship between decorative and morphometric traits was evaluated using the correlation coefficient (r). Statistical processing of the research results was carried out using dispersion and correlation analyses. Over three years (2021–2023), the vegetation period of the studied varieties typically began in the second or third ten-day period of March. For all varieties except 'Minerva', vegetation ended with the onset of frost. On average, floribunda roses exhibited a growing season of 245 days, with the longest period recorded for 'Goldelse' (250 days) and the shortest for 'Minerva' (217 days). The mean flowering duration was 124 days across the study years, with the longest flowering observed in 'Pomponella' (145 days) and the shortest in 'Minerva' (94 days). In 2022, flowering duration was shortest (120 days), likely due to increased temperatures and reduced precipitation during the active growth phase. In the same year, flowering breaks totaled 25 days. The results confirm the significant influence of climatic conditions, particularly air temperature and precipitation, on the duration and dynamics of floribunda rose flowering. A strong positive correlation was identified between flowering duration and both the average air temperature during the active growing season (r = 0.90) and the number of days exceeding 15°C (r

= 0.84). Conversely, precipitation levels showed a strong negative correlation with the total duration of flowering breaks (r = –0.96). Thus, floribunda roses can be regarded as continuously flowering plants with a flowering period of up to 145 days, the intensity and dynamics of which depend on air temperature and precipitation. To increase flowering duration by reducing breaks, it is recommended to carry out additional irrigation and watering during dry periods. Also, given the global trends in climate change, the search for, creation, and study of drought-resistant rose genotypes is promising and may be a prospect for further research.

Keywords
Decorative qualities; Flowering; Phenological dDevelopment; Roses; Vegetation

Introduction

Changes in climatic conditions, manifested in sharp fluctuations in air temperature, excess or deficiency of atmospheric precipitation, changes in the hydrological regime, and more, constitute environmental risks that affect plant growth and development (Abobatta, 2023; Prykhodko, 2013; Singh *et al.*, 2023). The ability of plants to adjust growth and development rhythms is a key mechanism in forming resilience to adverse environmental conditions (Chaudhry and Sidhu, 2022; Branco *et al.*, 2022; Bulakh, 2005; Fahad *et al.*, 2021). Adaptation is a crucial factor that enables plants to adjust to specific environmental conditions, enhances the organism's resistance, and supports its optimal development under new growth circumstances (Giordano *et al.*, 2021; Kisvarga *et al.*, 2023; Prysedskyi and Lykholat, 2017). An important aspect in assessing the adaptation level of introduced plant species is the study of their seasonal phenorhythms. Although plant seasonal development is influenced by a complex array of meteorological factors, air temperature and precipitation are considered the most dominant (Currier and Sala, 2022; Kendzora, 2019; Mishra *et al.*, 2025).

Different rose varieties, including floribundas, have shown significant shifts in phenophase timing in response to climate change in the steppe zone of Ukraine over the past two decades (Chypyliak, 2020). This indicates greater variability in vegetative-phase timing than in generative phases of rose varieties. For instance, the duration of vegetation in floribunda rose varieties increased on average by 14 days, which is associated with the earlier onset of shoot growth (by 11–14 days). Flowering duration either remained unchanged or decreased by 45–48%. Under mild winter conditions, the phenological phases of rose development and organogenesis occur earlier. In contrast, extreme winter temperatures and significant periodic freezing result in damage to generative buds, leading to delays in growth and development as well as a reduction in both the duration and ornamental value of flowering (Tkachuk, 2015). Low temperatures slow down the rate at which metabolic reactions can occur in plants, leading to photooxidative damage to the photosynthetic apparatus and, consequently, to damage or death of plants (Ensminger, Busch and Huner, 2006; Ouyang *et al.*, 2022). The impact of stress factors also leads to a disruption in flowering and a decrease in its productivity, which in turn changes the market value of ornamental crops and, accordingly, profits (Pooja *et al.*, 2024).

Given documented rose responses to climatic variability and the continuing intensification of climate change on global and regional scales, further research on the

influence of abiotic factors on the growth and development of floribunda rose varieties is timely and highly relevant. Such studies are crucial for advancing adaptive strategies in ornamental horticulture and optimizing the cultivation of resilient rose varieties under shifting environmental conditions. This study aimed to assess the influence of abiotic factors on the growth and developmental characteristics of floribunda rose varieties under the cultivation conditions of the Right-Bank Forest-Steppe of Ukraine. The objective of the study was to determine the level of influence of changes in temperature and precipitation on the duration of flowering of floribunda roses.

Methodology

Study Area

Research on the growth and development characteristics of floribunda rose varieties under the conditions of the Right-Bank Forest-Steppe of Ukraine was carried out at the experimental plots of the Department of Landscape Gardening, Uman National University, over the period 2021–2023. The research material consisted of an introduced collection of roses, including 20 floribunda rose varieties: Pomponella, Lovely Green, Carmagnola, Arthur Bell, Lilli Marleen, Westpoint, Minerva, Novalis, Goldelse, Rotkappchen, Friesia, Lavaglut, Iceberg, Santa Monika, Henri Matisse, Bella Rosa, Cream Abundance, Hans Gonewein, Let's Celebrate, and Gebruder Grimm. The varieties differ in origin, ornamental traits, and stress resistance to agroclimatic environmental factors.

Soil and Weather Conditions

The climate of the study area is determined by the proximity of the city of Uman to the steppe zone of the temperate zone and is moderately continental with mild winters and warm summers. Significant climatic variability was observed over the research years in its territory. According to data from the Uman weather station, the average annual air temperature ranged from 8.7°C in 2021 to 10.7°C in 2023 (Figure 1). The highest average annual relative humidity was recorded in 2021 at 77.1%, while in other years it was slightly lower, with the minimum value (72.0%) observed in 2022.

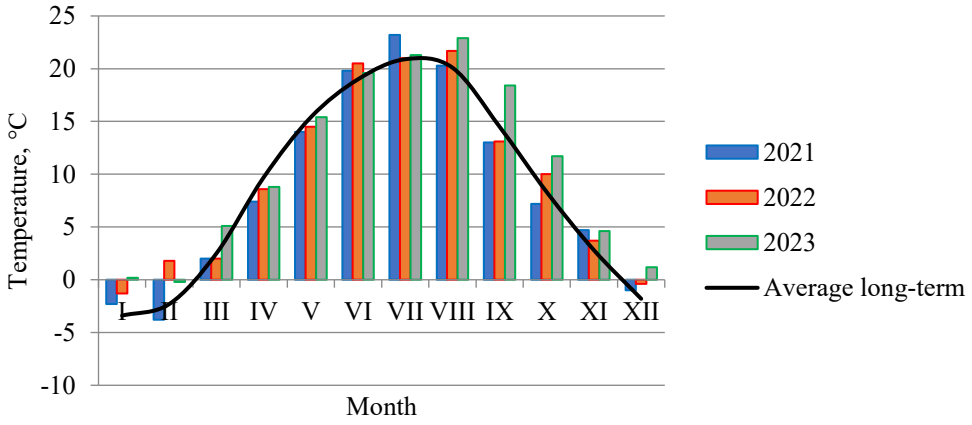

Figure 1: Average monthly air temperature during the research period (2021-2023)

The total amount of precipitation in 2022 was the lowest during the entire study period, amounting to 467.5 mm, which is 69.3 mm below the long-term average (Figure 2). The highest level of precipitation was recorded in 2021, reaching 641.6 mm.

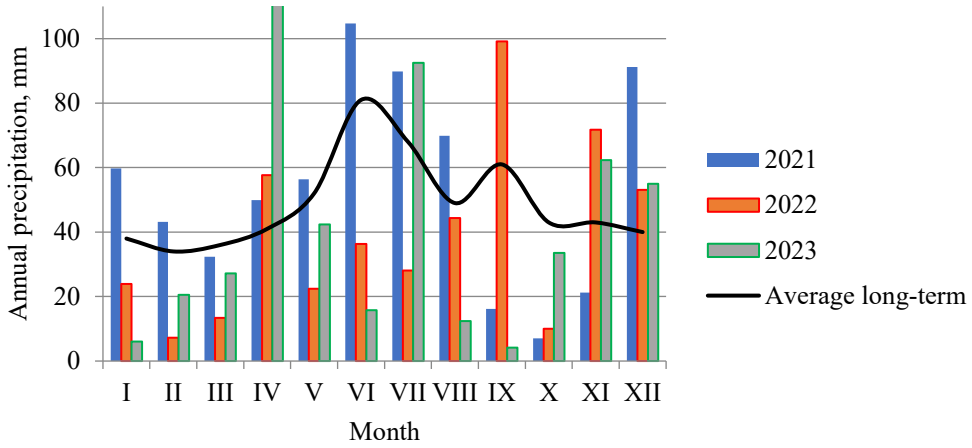

Figure 2: Average monthly precipitation during the study period (2021-2023)

The soils at Uman National University of Horticulture are classified as podzolized, heavy loam chernozems with low humus content. The arable layer contains a relatively low amount of humus (3.31%) and is characterized by a cloddy-dusty structure. In terms of the content of available (mobile) forms of phosphorus and potassium, the soil is classified as moderately supplied (80–130 mg/kg of soil). It has a neutral pH reaction (6.5–6.7) and is characterized by low capillary rise capacity (Polishchuk, 2003). For the accuracy of the experiment on the influence of climatic factors on plant development, additional irrigation and watering, as well as fertilization, were not carried out. Organic fertilizer (humus) was applied once to the planting hole only when planting plants. To combat and prevent disease and pest damage to rose varieties, the plants on the experimental plot were treated with chemical plant protection products and pruned. During the growing season, the following fungicides were applied: Blues, KS (kresoxim-methyl, 100 g/l + difenoconazole, 200 g/l); Flint Star 520SC, KS (trifloxystrobin, 120 g/l + pyrimethanil, 400 g/l), and the insecticidal biological product Actofit, KE (Aversectin C, 0.2%). Plants were pruned annually in spring before vegetation began, during vegetation after flowering, and in the fall after the plants had completely lost their decorative appeal.

Research Methods

Phenological observations of the main growth phases of floribunda rose varieties under the conditions of the Right-Bank Forest-Steppe of Ukraine were conducted according to standard methodology (Ukrainian Institute for Plant Variety Examination, 2016). Observations begin in early spring, about a week before the start of vegetation, and ended in autumn, after the end of vegetation. The phenophase dates were recorded based on the following signs: the beginning of bud break, the beginning of shoot growth, the beginning of bud formation, the beginning of flowering, the end of flowering, and the end of vegetation.

To determine the date of bud break, observations are carried out every two days, at the onset of the flowering phase, every day. Each treatment was replicated six times. Each repetition was one plant. The planting scheme was 2.0 × 1.0 meters, with a planting depth of 50 cm. This distance is sufficient for optimal development of floribunda roses and prevents overcrowding of plantings.

Statistical Analysis

Morphometric and ornamental traits were evaluated throughout the vegetation period, and the strength of relationships among key phenological and decorative characteristics was assessed using Pearson's correlation coefficient (r). The magnitude of r was interpreted according to established criteria: values <0.33 were considered weak correlations; 0.33–0.67, moderate; and >0.67, strong. The sign of r indicated the direction of the association — positive or negative (Kaminskyi and Buslaieva, 2011). The statistical processing of the obtained research results was carried out using ANOVA variance and Pearson's correlation analyses (Yeshchenko *et al.*, 2014) using Excel and Statistica 10 software.

Results

Across all study years, onset and completion of key developmental phases of floribunda rose varieties was recorded under the experimental conditions (Figure 3). Based on the phenological observations, it was established that the duration of the growing season and flowering are strongly shaped by climatic conditions as well as the individual growth and developmental characteristics of the studied varieties. Buds initiated in autumn opened under favorable spring conditions. In all examined varieties, bud break generally occurred in March–April, which corresponds to the typical timing for floribunda roses grown under southern climatic conditions.

Vegetation Period

The earliest onset of vegetation during the study period was observed in the Westpoint and Minerva varieties, while the latest was recorded in Pomponella and Bella Rosa.

In all varieties, the end of the vegetation period coincided with the onset of frost. The only exception was Minerva, which completed its growing season in the second ten-day period of October, when air temperatures dropped below +10°C, likely due to varietal ontogenetic characteristics. The average duration of the vegetation period across the studied varieties was 245 days, with the longest observed in Goldelse (250 days) and the shortest in Minerva (217 days) (Table 1). These findings reflect the adaptability of floribunda roses to extended warm seasons and highlight genotypic differences in vegetative persistence.

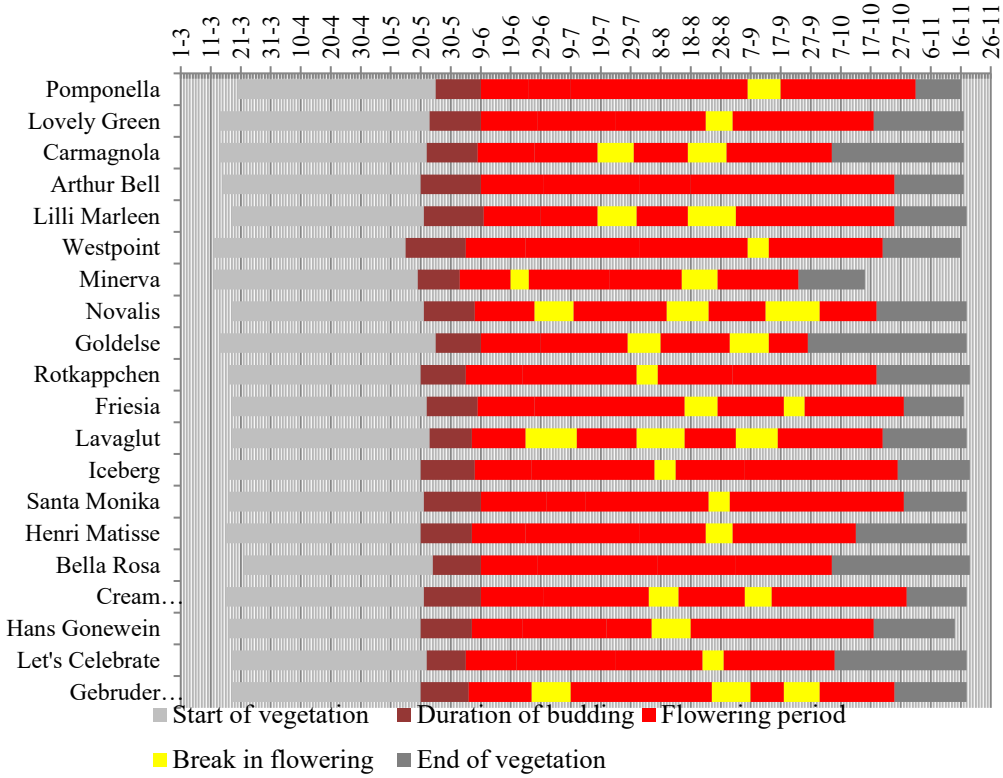

Figure 3: Seasonal development rhythms of floribunda roses (2021–2023)

Table 1: Vegetation period of floribunda roses (2021-2023)

Variety	*Vegetation period, days*			
	2021	*2022*	*2023*	*Average*
Pomponella	230	231	269	243
Lovely Green	235	238	272	248
Carmagnola	234	238	275	249
Arthur Bell	232	238	275	248
Lilli Marleen	231	233	272	246
Westpoint	234	238	275	249
Minerva	199	206	247	217
Novalis	230	236	269	245
Goldelse	235	240	276	250
Rotkappchen	233	240	269	248
Friesia	231	231	272	244
Lavaglut	233	238	267	246
Iceberg	233	238	273	248
Santa Monika	233	238	269	246
Henri Matisse	234	240	272	248
Bella Rosa	230	233	266	243
Cream Abundance	234	238	269	247
Hans Gonewein	236	242	265	247

Variety	*Vegetation period, days*			
	2021	*2022*	*2023*	*Average*
Let's Celebrate	233	238	265	245
Gebruder Grimm	234	236	267	245
LSD_{05}	11,56	11,78	13,46	12,26

Influence of Spring Temperature on Budding

The cold spring of 2022, accompanied by unfavorable meteorological conditions such as night frosts on the soil surface, led to a delayed onset of the budding phase. On average, budding began on May 25, three days later than in 2021 and nine days later than in 2023. Despite the earlier timing of bud initiation in general, the duration of bud formation was the longest in 2023. This was mainly due to the unusually early onset of vegetation: the stable transition of average daily temperatures above +5 °C occurred 19 and 14 days earlier than in 2021 and 2022, respectively. Fluctuating temperatures and recurrent frosts prolonged generative-organ development. On average, buds formed 84 days after vegetation onset in 2023, compared to 54 and 58 days in 2021 and 2022, respectively (Table 2).

Table 2: Duration of the period from bud break to the onset of budding, 2021–2023

Variety	*Vegetation period, days*			
	2021	*2022*	*2023*	*Average*
Pomponella	230	231	269	243
Lovely Green	235	238	272	248
Carmagnola	234	238	275	249
Arthur Bell	232	238	275	248
Lilli Marleen	231	233	272	246
Westpoint	234	238	275	249
Minerva	199	206	247	217
Novalis	230	236	269	245
Goldelse	235	240	276	250
Rotkappchen	233	240	269	248
Friesia	231	231	272	244
Lavaglut	233	238	267	246
Iceberg	233	238	273	248
Santa Monika	233	238	269	246
Henri Matisse	234	240	272	248
Bella Rosa	230	233	266	243
Cream Abundance	234	238	269	247
Hans Gonewein	236	242	265	247
Let's Celebrate	233	238	265	245
Gebruder Grimm	234	236	267	245
LSD_{05}	11,56	11,78	13,46	12,26

Flowering Dynamics

When studying rose varieties, particular attention is given to flowering timing and duration, as these are among the most important traits for ornamental horticulture. In floribunda rose varieties, the onset of flowering was recorded between the third ten-day period of May and the second ten-day period of June (Figure 1). The average flowering duration among floribunda varieties was 124 days, with the longest period observed in Pomponella (145 days) and the shortest in Minerva (94 days) (Table 3). Although growing-season duration depended mainly on temperature, flowering dynamics were influenced by a more complex interplay of climatic factors, including precipitation, temperature fluctuations, and humidity.

Table 3: Flowering duration of floribunda rose varieties (2021-2023)

Variety	*Flowering duration, days*			
	2021	*2022*	*2023*	*Average*
Pomponella	149,33	138	147	145
Lovely Green	146,33	138	145	143
Carmagnola	116,33	116	111	114
Arthur Bell	148,00	150	150	149
Lilli Marleen	112,00	110	110	111
Westpoint	131,33	126	128	128
Minerva	91,17	102	96	94
Novalis	91,67	104	91	108
Goldelse	118,83	90	112	112
Rotkappchen	138,17	135	137	137
Friesia	130,33	105	135	124
Lavaglut	91,17	94	93	93
Iceberg	136,50	121	134	131
Santa Monika	134,00	125	130	130
Henri Matisse	138,33	132	138	136
Bella Rosa	133,33	132	135	133
Cream Abundance	120,17	127	128	125
Hans Gonewein	132,17	120	133	128
Let's Celebrate	133,67	124	131	129
Gebruder Grimm	111,50	104	112	109
LSD_{05}	6,26	5,98	6,24	6,16

Impact of Drought in 2022

Across the years of observation, 2022 had the shortest flowering period for most varieties, associated with notably dry conditions (Figure 4). During this year, the cumulative duration of flowering breaks increased to 25 days, 16 days longer than in 2021 and 10 days longer than in 2023. These prolonged interruptions indicate heightened plant stress caused by insufficient moisture.

Interestingly, despite the pronounced drought, total flowering duration decreased by only five days compared to other years, uggesting that several varieties possess resilience mechanisms allowing continued flowering under moisture limitation.

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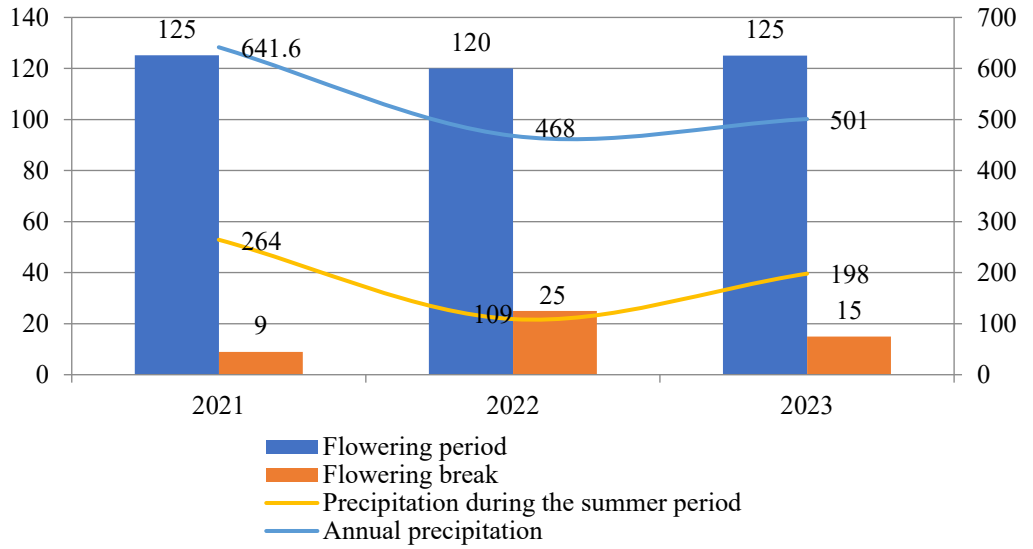

Figure 4: Variation in flowering duration of floribunda rose varieties in relation to total precipitation during the corresponding period (2021–2023)

The analysis of plant responses to agroclimatic conditions during the study period (2021–2023) confirmed the significant impact of various factors on the ornamental traits of the examined genotypes (Table 5).

Correlation Between Phenological Traits and Climatic Factors

Correlation analysis revealed clear relationships between flowering behavior and key climatic indicators (Table 5).

Table 4: Correlation coefficients between flowering duration and climatic conditions, 2021–2023

Correlated indicators	*Flowering duration, days*	*Break in flowering, days*
Average air temperature during the active growing season, °C	0,90	-0,03
Average air temperature in summer, °C	-0,57	0,64
Total precipitation during the active growing season, mm	-0,28	-0,72
Total precipitation during the summer, mm	0,19	-0,96
Average air humidity during the active growing season, %	-0,08	-0,79
Average air humidity during the summer, %	0,27	-0,98
Number of days with air temperature above:	0,84	-0,10
15 °C		

Correlated indicators	*Flowering duration, days*	*Break in flowering, days*
10 °C	0,50	0,57
Break in flowering, days	-0,46	-
LSD_{05}	0,01	0,01

It was established that climatic factors during the active growing season and summer period have the most significant influence on the duration and dynamics of flowering. Roses generally begin mass flowering once temperatures consistently exceed 15 °C. The earlier this threshold is reached in spring, the longer the flowering period tends to be, provided there are no early autumn frosts. According to the results presented in table 5, a strong positive correlation was found between flowering duration and both the average air temperature during the active growing season ($r = 0.90$) and the number of days with air temperatures above 15 °C ($r = 0.84$). A moderate negative correlation with average summer air temperature ($r = –0.57$) indicates a reduction in flowering duration during hot and dry periods.

The negative impact of precipitation deficit and insufficient moisture during the study period was reflected in the increased number and length of flowering breaks in floribunda rose varieties. A strong negative correlation was observed between the total duration of flowering breaks and both precipitation levels and average air humidity. The highest correlation coefficients were recorded for total summer precipitation ($r = –0.96$) and average summer humidity ($r = –0.98$). A significant positive correlation was also found between the average summer air temperature and the duration of flowering breaks ($r = 0.64$). Because flowering breaks reduce overall flowering duration ($r = –0.46$), there is a clear need for additional agrotechnological measures—such as irrigation and watering during dry periods—to reduce interruptions in flowering and enhance ornamental value during the blooming season.

Discussion

Roses (*Rosa* L.) have been among the most important ornamental plants since ancient times and are now widely cultivated across the globe. The primary centers of origin for roses are thought to be are located in North and South Asia, as well as the Middle East (Ukrainets and Polishchuk, 2022). From these regions, representatives of *Rosa* L. were introduced and gradually spread throughout most of Europe, as well as central and eastern North America (Yang *et al.*, 2024). In Ukraine, the first historical references to roses date back to the 19th century (Rubtsova, 2009). It has been established that the broad geographical distribution and extensive cultivation of roses increase their sensitivity to adverse environmental conditions, particularly soil drought, and contribute to abiotic stress, which negatively affects plant growth and flowering performance (Amiri, Nikbakht and Etemadi, 2015; Geng *et al.*, 2022).

Previous studies confirm that water deficiency markedly reduces floral traits such as the number of flowers, flower size, flowering duration, and overall decorative value (Aalam *et al.*, 2024; Zarif *et al.*, 2025). Our observations in the Right-Bank Forest-Steppe of Ukraine align with these findings: a precipitation deficit had a clear impact on flowering.

The shortest flowering duration (104 days on average) was recorded in 2022, the driest year of the study period.

Observations revealed that precipitation deficits directly affected on the flowering period of floribunda roses. On average, the shortest flowering duration, 104 days, was recorded in 2022, which was characterized by the most severe drought conditions. However, despite a 51% reduction in total annual precipitation and a 59% reduction during the peak flowering period (June–September), the overall flowering duration of floribunda varieties decreased by only 7.5 days (6.7%). In contrast, the same level of precipitation reduction led to a 16-day increase in the duration of flowering breaks, 2.8 times longer than in more favorable years. These findings underscore the need for supplemental irrigation during dry summer periods. Overall, the results indicate that the flowering performance of roses depends on a complex interplay of factors during the growing season. This highlights the need for further research on varietal responses to abiotic stressors and developing adaptive agrotechnological strategies.

Global climate change is a major international issue that significantly affects the development and functioning of both natural and economic systems (Maksymova *et al.*, 2024). Its consequences have a considerable impact on regional weather conditions, including land surface temperature, precipitation levels, and the growth and development of plants (Islam and Ma, 2018; Islam *et al.*, 2019; Islam *et al.*, 2023; Zhu *et al.*, 2020). Climate change represents a highly unpredictable domain of environmental transformation in the short term. In this context, scientists are actively seeking statistical patterns and predictive models to assess the impact of climate change on natural ecosystems (Ivanyshyn and Kasiyanchuk, 2024; Marusig *et al.*, 2020; Patil *et al.*, 2024). Evaluating the influence of environmental factors can assist in implementing potential adaptation and mitigation strategies. Globally, quantitative assessment has become a standard method for evaluating the frequency and intensity of plant vulnerability to climate change, as well as for identifying measures to prevent negative outcomes (Hossain and Atibudhi, 2024).

Recent studies have demonstrated that an increase in air temperature during the early and full flowering stages of roses, from 22.3 °C to 25.1 °C, results in a shorter flowering period. This relationship is supported by a moderate negative correlation (Spearman's coefficient: –0.53237), indicating that rising air temperatures moderately reduce the main flowering phase. These findings are consistent with the results obtained under the conditions of the Right-Bank Forest-Steppe of Ukraine, where the effect of summer air temperature during the active growing period was similarly significant ($r = –0.57$) (Ljubojevic *et al.*, 2025).

Under the same regional conditions, an analysis was conducted to examine how the duration of periods with specific temperature thresholds influenced rose flowering. A moderate correlation was found between flowering duration and the number of days with air temperatures above 10 °C ($r = 0.50$), while a strong correlation was observed for days exceeding 15 °C ($r = 0.84$). Research conducted by Ljubojević and colleagues further confirmed the role of accumulated effective temperatures in determining both the onset and duration of flowering in roses. For *Rosa rugosa* Thunb., flowering was initiated after

the accumulation of 559.6 °C to 1049.2 °C, while flowering ended once accumulated temperatures reached 2273.3 °C to 3729.5 °C.

Given that the findings on floribunda rose varieties also suggest the potential significance of effective temperature accumulation on flowering timing, further investigation into this factor is warranted. In particular, considering that the *Minerva* variety exhibited the shortest flowering duration (94 days) and that flowering ceased long before air temperatures dropped below 0 °C, unlike other studied varieties, examining the role of accumulated heat units becomes a priority direction for future research under comparable environmental conditions.

Conclusion

Over three years of observation (2021–2023), it was determined that under the conditions of the Right-Bank Forest-Steppe of Ukraine, the growing season for floribunda rose varieties began during the second to third ten-day period of March. For most varieties, the growing season ended in the second ten-day period of November with the onset of sustained frosts. An exception was the *Minerva* variety, whose flowering ended earlier, in the third ten-day period of September. The average duration of the growing season among floribunda roses was 245 days, with the longest period recorded in the *Goldelse* variety (250 days) and the shortest in *Minerva* (217 days). The average flowering duration across varieties was 124 days. The longest flowering period was observed in *Pomponella* (145 days), and the shortest in *Minerva* (94 days). Among the years studied, the shortest flowering period was recorded in 2022, lasting 120 days, which was likely due to dry climatic conditions and insufficient precipitation during the active growing season. In 2022, flowering breaks increased to 25 days was recorded, which negatively affected the overall ornamental quality of roses during the summer period. The study confirmed a significant influence of climatic factors during both the active growing season and the summer months on the duration and dynamics of flowering in floribunda rose varieties. In particular, a strong positive correlation was found between flowering duration and both the average air temperature during the active growing season ($r = 0.90$) and the number of days with temperatures exceeding 15 °C ($r = 0.84$). Conversely, a strong negative correlation was observed between the duration of flowering breaks and the amount of precipitation, both in summer ($r = –0.96$) and throughout the active growing season ($r = –0.72$). Overall, the study highlights the significant influence of climatic variability on the phenological development of floribunda roses and emphasizes the importance of adopting adaptive horticultural practices, particularly under increasing climate instability.

Based on the results, we recommend that in dry years with maximum precipitation deficits, most varieties of floribunda roses should be additionally watered and irrigated to improve their overall condition, maintain their decorative appearance, and prevent additional and prolonged interruptions in flowering. Additional irrigation may be unnecessary for drought-resistant varieties, Carmagnola and Bella Rosa, in which no signs of changes in plant condition under dry conditions have been found.

References

Aalam, F., Rezaei Nejad, A., Mousavi-Fard, S., Raji, M., Nikoloudakis, N., Goumenaki, E. and Fanourakis, D. (2024). Water Deficit Severity during the Preceding Year Determines Plant Tolerance to Subsequent Year Drought Stress Challenges: A Case Study in Damask Rose. *Horticulturae,* 10: 462. DOI: https://doi.org/10.3390/horticulturae10050462.

Abobatta, W.F. (2023). The influence of climate change on interactions between environmental stresses and plants. *Plant Stress Mitigators*, 425-434. DOI: https://doi.org/10.1016/B978-0-323-89871-3.00021-5.

Amiri, R., Nikbakht, A. and Etemadi, N. (2015). Alleviation of drought stress on rose geranium [*Pelargonium graveolens* (L.) Herit.] in terms of antioxidant activity and secondary metabolites by mycorrhizal inoculation. *Scientia Horticulturae*, 197: 373-380. DOI: https://doi.org/10.1016/j.scienta.2015.09.062.

Branco, S., Schauster, A., Liao, H.L. and Ruytinx, J. (2022). Mechanisms of stress tolerance and their effects on the ecology and evolution of mycorrhizal fungi. *New Phytologist*, 235(6): 2158-2175. DOI: https://doi.org/10.1111/nph.18308.

Bulakh, P.E. (2005). Phenological criteria for sustainability in plant introduction. *Plant Introduction*, 4: 9-19. DOI: https://doi.org/10.5281/zenodo.2584211.

Chaudhry, S. and Sidhu, G.P.S. (2022). Climate change regulated abiotic stress mechanisms in plants: a comprehensive review. *Plant Cell Reports*, 41(1): 1-31. DOI: https://doi.org/10.1007/s00299-021-02759-5.

Chypyliak, T.F. (2020). Seasonal development of garden roses under climate change in the steppe conditions of Ukraine. *The European potential for development of natural science*: conference proceedings International scientific and practical conference. Lublin: Izdevnieciba 'Baltija Publishing', (pp91-95).

Currier, C.M. and Sala, O.E. (2022). Precipitation versus temperature as phenology controls in drylands. *Ecology*, 103(11): e3793. DOI: https://doi.org/10.1002/ecy.3793.

Ensminger, I., Busch, F.A. and Huner, N.P.A. (2006). Western UniversityPhotostasis and cold acclimation: sensing low temperature through photosynthesis. *Physiologia Plantarum*, 126(1): 28–44. DOI: https://doi.org/10.1111/j.1399-3054.2006.00627.x.

Fahad, S., Saud, S., Chen, Y., Wu, C. and Wang, D. (Eds.). (2021). Abiotic stress in plants. BoD–Books on Demand, 496. DOI: http://dx.doi.org/10.5772/intechopen.91549.

Geng, L., Su, L., Wang, Y., Geng, Z., Lin, S., Zhang, Y., Yu, S., Fu, L., Liu, Q. Cheng, C. and Jiang, X. (2022). Role of RcTINY2 in the Regulation of Drought and Salt Stress Response in Arabidopsis and Rose. *Horticulturae*, 8, 747. DOI: https://doi.org/10.3390/horticulturae8080747.

Giordano, M., Petropoulos, S.A., Cirillo, C. and Rouphael, Y. (2021). Biochemical, physiological, and molecular aspects of ornamental plants adaptation to deficit irrigation. *Horticulturae*, 7(5): 107.

Hossain, S.M. and Atibudhi, H. (2024). Agricultural Vulnerability to Climate Change: A quantitative assessment for Odisha. *Grassroots Journal of Natural Resources*, 7(2): 236-250. DOI: https://doi.org/10.33002/nr2581.6853.070212.

Islam, S., Adil, M., Ganguli, S. and Akter, N. (2023). Spatiotemporal Variations of Land Surface Temperature and Vegetation Dynamics Impacts on Landslide Intensity in Chattogram Hill Tracts Region of Bangladesh. *Grassroots Journal of Natural Resources*, 6(2): 19-37. DOI: https://doi.org/10.33002/nr2581.6853.060203.

Islam, S. and Ma, M. (2018). Geospatial monitoring of land surface temperature effects on vegetation dynamics in the Southeastern Region of Bangladesh from 2001 to 2016. *ISPRS International Journal of Geo-Information*, 7(12): 486. DOI: https://doi.org/10.3390/ijgi7120486.

Islam, S., Zhang, M., Yang, H. and Ma, M. (2019). Assessing inconsistency in global land cover products and synthesis of studies on land use and land cover dynamics during 2001 to 2017 in the southeastern region of Bangladesh. *Journal of Applied Remote Sensing*, 13(4): 048501. DOI: https://doi.org/10.1117/1.JRS.13.048501.

Ivanyshyn, V. and Kasiyanchuk, D. (2024). Analysis of the Impact of Climate Change on the Vegetation of the Perehinsk Territorial Community in Ukraine. *Grassroots Journal of Natural Resources*, 7(2): 199-215. DOI: https://doi.org/10.33002/nr2581.6853.070210.

Kaminskyi, V.F. and Buslaieva, N.H. (2011). Fundamentals of Applied Mathematical Analysis in Agricultural Research: Methodological Recommendations. Kyiv: Edelweiss, 28.

Kendzora, N.Z. (2019). Features of seasonal phenorhythmics of plants under the influence of meteorological factors in 2014-2018. Materials of the International Scientific and Practical Conference: *Current Status and Prospects for the Development of Landscape Architecture, Horticulture, Urban Ecology, and Phytomelioration*. Lviv, NLTU of Ukraine, 126-128.

Kisvarga, S., Horotán, K., Wani, M.A., and Orlóci, L. (2023). Plant responses to global climate change and urbanization: Implications for sustainable urban landscapes. *Horticulturae*, 9(9): 1051. DOI: https://doi.org/10.3390/horticulturae9091051.

Ljubojevic, M., Cukanovic, J., Dordevic, S., Petrov, D., Galecic, N., Skocajic, D. and Ocokoljic, M. (2025). Characterizing the Flowering Phenology of Rosa rugosa Thunb. as an Ecosystem Service in the Context of Climate Change in Kupinovo (Vojvodina). *Serbia. Plants*, 14(12): 1875. DOI: https://doi.org/10.3390/plants14121875.

Maksymova, I., Velhas, V., Tokunova, A., Pugachov, M. and Chichulina, K. (2024). Developing Strategies for Adapting Business Processes to Climate Change: Minimizing Risks in the Context of Global Climate Challenges. *Grassroots Journal of Natural Resources*, 7(3): s290-s312. DOI: https://doi.org/10.33002/nr2581.6853.0703ukr15

Marusig, D., Petruzzellis, F., Tomasella, M., Napolitano, R., Altobelli, A. and Nardini, A. (2020). Correlation of Field-Measured and remotely sensed plant water status as a tool to monitor the risk of drought-induced forest decline. *Forests*, 11(1): 77. DOI: https://doi.org/10.3390/f11010077.

Ukrainian Institute for Plant Variety Examination (2016). Methodology for conducting expert assessments of ornamental, medicinal, essential oil, and forest plant varieties for suitability for distribution in Ukraine: 2nd ed., rev. and expanded. Vinnytsia: Nilan-LTD, 130.

Mishra, N., Ray, M., Das, S., Ghosh, A. and Mandal, A. (2025). Climatic Controls of Marigold: Effect of Temperature and Rainfall on Growth and Yield of Marigold. *International Journal of Environment and Climate Change*, 15(7): 180-189. DOI: https://doi.org/10.9734/ijecc/2025/v15i74922.

Ouyang, L., Leu, L., Keyser, E.D. and Labeke, M.C.V. (2022). Temperature is an important driver for cold acclimation in garden roses. *Scientia Horticulturae*, 296(5): 110905. DOI: https://doi.org/10.1016/j.scienta.2022.110905.

Patil, P.P., Megha, P.J., Narendra, K., Hakka, M., Aditya, A.V. and Tarun P. (2024). Exploration and advancement of NDDI leveraging NDVI and NDWI in Indian semi-arid regions: A remote sensing-based study. *Case Studies in Chemical and Environmental Engineering*, 9: 100573. DOI: https://doi.org/10.1016/j.cscee.2023.100573.

Polishchuk, V.V. (2003). Experimental evaluation of inbred corn lines adapted to the conditions of the Forest-Steppe zone of Ukraine: dissertation. Candidate of Agricultural Sciences: 03.00.16. Kyiv, 176.

Pooja, M.S., Mohd, A., Manoj, N., Jatin, T., Hamid, F., Alaka, S.B. and Ashish P.S. (2024). The Impact of Climate Change on Flowering Patterns and Productivity in Floriculture: A Comprehensive Review. *Journal of Scientific Research and Reports*, 30 (11): 577-590. DOI: https://doi.org/10.9734/jsrr/2024/v30i112586.

Prykhodko, M.M. (2013). Environmental safety of natural and anthropogenically modified geosystems: monograph. Kyiv: Center for Environmental Education and Information, 201.

Prysedskyi, Yu. H. and Lykholat Y.V. (2017). Adaptation of plants to anthropogenic factors (textbook for students majoring in biology, ecology, and secondary education at higher educational institutions). Vasyl Stus Donetsk National University. Vinnytsia: Nilan-LTD LLC, 98.

Rubtsova, O.L. (2009). The genus *Rosa* L. in Ukraine: gene pool, history, research directions, achievements, and prospects: monograph. Kyiv: Phoenix, 375.

Singh, B.K., Delgado-Baquerizo, M., Egidi, E., Guirado, E., Leach, J.E., Liu, H. and Trivedi, P. (2023). Climate change impacts on plant pathogens, food security and paths forward. *Nature Reviews Microbiology*, 21(10): 640-656. DOI: https://doi.org/10.1038/s41579-023-00900-7.

Tkachuk, O. (2015). Analysis of the winter hardiness of roses in the Botanical Garden named after Academician O.V. Fomin under conditions of climate change. *Introduction and Preservation of Plant Diversity*, 1(33): 25-28.

Ukrainets, O. and Polishchuk, V. (2022). Clonal Micropropagation, Rhizogenesis and Adaptive Capacity of Certain Rose (*Rosa* L.) Variety Explants. *Grassroots Journal of Natural Resources*, 5(1): 47-56. DOI: https://doi.org/10.33002/nr2581.6853.050104.

Yang, S., Wang, H., Jing, W., Wang, Q., Yan, H., Qiu, X. and Jian, H. (2024). Simulation of climate change effect on the global distribution of *Rosa multiflora*. *Chinese Journal of Applied Ecology*, 35(07). DOI: https://doi.org/10.13287/j.1001-9332.202407.022.

Yeshchenko, V.O., Kopytko, P.H., Kostohryz, P.V., Opryshko, V.P. (2014). Fundamentals of Scientific Research. Vinnytsia: PPTD 'Edelweiss and K', 332.

Zarif H., Fan C., Yuan G., Zhou R., Chang Y., Sun J., Lu J., Liu J. and Wang C. (2025). Drought Stress in Roses: A Comprehensive Review of Morphophysiological, Biochemical, and Molecular Responses. *International Journal of Molecular Sciences*, 26(9): 4272. DOI: https://doi.org/10.3390/ijms26094272.

Zhu, K.W., Chen Y.C., Zhang, S., Yang, Z.M., Huang, L., Li, L., Lei, B., Zhou, Z.B., Xiong, H.L., Li, X.X., Li, Y.C. and Islam, S. (2020). Output risk evolution analysis of agricultural non-point source pollution under different scenarios based on multi-model. *Global Ecology and Conservation*, 23: e01144. DOI: https://doi.org/10.1016/j.gecco.2020.e01144.

Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*	*Author 4*	*Author 5*	*Author 6*	*Author 7*	*Author 8*	*Author 9*	*Author 10*
Conceived and designed the research or analysis	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Collected the data	Yes	No	No	No	No	No	No	No	No	No
Contributed to data analysis & interpretation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Wrote the article/paper	Yes	No	No	No	No	No	No	No	No	No
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